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MONSANTO CHEMICAL COMPANY
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OSTI

PRESERVATION OF LABORATORY INSTRUMENTS IN STATIC STORAGE

(Information Report)

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I. INTRODUCTION

It is desirable to place laboratory instruments in static storage so that they may be put into operation with only normal servicing. Such instruments may be subject to many forms of deterioration. There may be deterioration of metal parts due to chemical and electrolytic corrosion and the effects of moisture, excessive dryness, and microorganisms, i.e., mildew on organic parts. Ref. 1, 2, 3.

To preserve such instruments without disassembly or troublesome surface coatings, requires methods that will remove the major cause of deterioration - that is, excessive humidity, by reducing and maintaining the relative humidity of the air surrounding the item at 30 per cent or less. It is also necessary to eliminate or separate hygroscopic materials from the item since they will cause corrosion, by surface adsorption and condensation, even though a dry atmosphere is maintained. Ref. 3.

The methods and materials used must not only be efficient and economical but also require a minimum of maintenance.

Protection against physical damage and temperature extremes is dependent upon the storage site and is not considered in this report.

II. CONCLUSIONS

Although central storage is a feasible solution to the problem, it was dropped from consideration at this time because complete information on mechanical dehumidifiers was unobtainable. Individual packaging is an inexpensive and efficient method of preservation. The recommended treatment for three classes of equipment is outlined as follows:

A. Portable

Storage items may be placed into a heat-sealable pouch fabricated from a flexible, laminated barrier material containing the proper window, humidity indicator, and quantity of desiccant.

Small items may be placed in a glass or metal container as a substitute for the pouch.

B. Movable

Items may be placed upon a metal tray and enclosed with a spray

barrier (including an asphaltic outer film); suitable windows, relative humidity indicators, and desiccant added.

A prefabricated sheet metal barrier may be used in place of the spray material.

C. Fixed

(Particular care must be given to the surface to which the storage item is secured.)

Items contained in resonably solid metal housings or cases may be preserved by placing an adequate desiccant and a relative humidity indicator inside and sealing the openings with moisture-vapor resistant tape.

Items may be enclosed with a barrier composed of spray materials (plus an outer asphaltic film); suitable windows, relative humidity indicators, and desiccant added.

III. INVESTIGATIONS

At the outset of the investigation, the original intent was to conduct a series of moisture-vapor permeability tests upon various packaging materials. Following this course, the first portion was devoted to the fabricating and testing of sample packages. Due to the lack of expensive testing equipment (Ref. 3, 7, 8) the testing procedure involved placing a known weight of desiccant in sealed vinyl and polyethylene envelopes. (No other material was available at the time.) These packages were then placed in an air-conditioned room (maintained at 68°F. and 50 per cent relative humidity) and weighed every 24 hours for a period of 168 hours. The results showed that the moisture-vapor transmission rates were: vinyl (eight mils thick) 0.25 grams per 100 square inches per 24 hours; polyethylene (five mils thick) 0.10 grams per 100 square inches per 24 hours.

This test method did not reproduce the extreme conditions that might be encountered. Also, since it consumed more time than was justifiable, and was limited to materials available, it was decided to abandon the original plan in favor of a library research program.

A. Types of Instruments

The types of instruments to be stored may be divided into three classes: portable - that is easily handled; movable - that is moved with difficulty; and fixed or permanent installations. The latter two classes are instruments deemed inadvisable to move from their normal locations due to bulk or fragility of the item or permanence of installation.

B. Standard Methods of Preservation

Two standard methods of preservation were considered, central and individual. The effectiveness of these methods depends upon the following factors: Ref. 3, 20, 21.

1. Volume of enclosed space.
2. Surface area of the barrier.
3. Moisture-vapor transmission rate of the barrier.
4. Quantity of dehydrating agent included (or the efficiency of the dehumidifying machinery).

1. Central Preservation Method

The central preservation method requires a reasonably moisture-vapor proof storage room, a mechanical dehumidifier of sufficient capacity to maintain the proper humidity, and dust protection for the individual items. The room, to be moisture-vapor proof, should be lined with metal or have the surfaces treated with a moisture-vapor proof compound. One type of mechanical dehumidifier in general use at this time utilizes either an adsorbent or an absorbent as a dehumidifying agent. Ref. 4, 10 These units are complex mechanisms requiring regenerative cycles for reactivation. Another type of dehumidifier operates on the refrigeration principle, and one model will be available locally in the near future. Ref. 12, 13 Although this machine is not designed for our specific purpose, it is conceivable that it might be a satisfactory and inexpensive solution. Accurate information on either type of mechanical dehumidifier is unobtainable at this time. The advantages of this method for storing little-used equipment are evident.

2. Individual Package Method

The individual package method consists of placing the instrument in a suitable moisture-vapor proof, sealable container along with sufficient desiccant to reduce the humidity to a safe level, a relative-humidity indicator for inspection purposes, and the separation or elimination, whenever possible, of any hygroscopic materials from the item. Ref. 1 This method is especially adaptable to situations where it is desirable or necessary to store the instruments in the location where it is to be used.

a. Cleaning and Preservative Oils

Cleaning and preservative oils vary greatly with the type of instrument to be stored, therefore, no universal set of rules may be given. Certain general factors which govern the proper cleaning of items before packaging are:

1. Cleaning material which may attack the part chemically or leave injurious residues should not be used.

2. Certain complex assemblies should not be cleaned in the assembled state.

3. Organic contaminates such as oil or grease should be removed by either solvent or alkaline cleaning.

4. Contamination of highly finished surfaces by perspiration should be removed by organic solvents followed by a methanol bath.

Detailed instructions for most types of materials are set forth in Reference 21.

b. Moisture-Vapor Proof Barriers

A complete guide to moisture-vapor transmission rates for various thicknesses of materials is not available, possibly due to the fact that it is not generally required and that tentative systems for testing have only been set up in recent years. The American Society for Testing Materials has set tentative systems for testing permeability (Ref. 7, 8) and the Armed

Forces have adopted similary methods for determining material specifications. Ref. 18 The transmission rates for flexible barrier materials vary with manufacturing efficiency and techniques. No true evaluation can be made without extensive performance tests. Ref. 2

Moisture-vapor proof barriers that are applicable to the problem may be divided into two general classifications: prefabricated (flexible and solid) and spray; the use depending upon the size and shape characteristics of the instrument to be preserved. (In a few instances, the instrument case itself might serve as a suitable barrier.)

(1) Flexible Films and Sheets

Prefabricated flexible barriers of sheet, film, or laminated materials are obtainable commercially in flat-bottomed bags or envelope-shaped pouches with sealed-in transparent windows for observation of relative humidity indicators. Ref. 3 The pouch size may easily be calculated for objects by the formulas: Ref. 16

Width + length + clearance allowance = width (inside dimension). (1)
Width + height + sealing allowance = depth (inside dimension). (2)

Example:

The dimensions of an instrument are 5 inches wide by 20 inches long by 10 inches high; seal to be across the top.

5 inches + 20 inches + 4 inches = 29 inches (1)
and
5 inches + 10 inches + 8 inches = 21 inches (2)

Thus, the pouch size would be 29 inches by 21 inches inside dimensions. In this case the seal is on the 29 inch side.

(2) Flexible Laminates

Since no single material exists that would satisfy all conditions desired of a flexible barrier, laminations of various materials are manufactured using specific materials to satisfy certain conditions.

The most efficient of the laminates are those based on aluminum foil as the moisture-vapor barrier which have a negligible transmission rate. Since the foils are subject to pinholing and breakage due to creasing and folding, the materials must be considered on the basis of the physical characteristics of the backing, laminating, and heat-sealing materials. Ref. 16

(3) Solid Barriers

Solid barriers are composed of glass or sheet metal. Although glass containers are obviously limited in size, sheet metal is easily fabricated to accomodate unlimited sizes and shapes. Extreme caution must be observed, when fabricating metal containers, to insure perfectly air-tight seams. A simple solution to pinholes in soldered joints is to treat the soldered area with an asphaltic compound.

An easily constructed metal barrier consists of a base plate and a cover which conforms as nearly as practical to the physical dimensions of the storage item. The instrument is placed upon the base and the cover fitted over it and sealed to the base. An economical and convenient seal may be obtained by filling the joint with a melted wax composed of equal parts of crude beeswax and wood or gum resin. Ref. 7 A good asphaltic compound may also be used for this purpose. These containers are expensive to fabricate but afford the best possible protection. (Table I.)

(4) Spray Barriers

The most common type of spray barrier consists of a vinyl-plastic coating sprayed directly on the item or on a suitable supporting material. Since these spray materials are vinyls or similar plastics and are applied as a spray, they are not satisfactory moisture-vapor barriers in themselves, but are useful as an envelope to support asphaltic compounds which have low moisture-vapor transmission rates. Ref. 9 These spray barriers have definite advantages in as much as they conform to the exact physical characteristics of the stored item; thus, reducing the cubic content and surface area of the container. This reduction is especially advantageous in the case of bulky irregularly shaped items. These coatings do not adhere to the surface of the storage item and are easily stripped off when the item is to be used.

Sufficient ventilation should be supplied to remove any health and safety hazards presented by the solvents in these materials.

(5) Paper Impregnates or Coatings

These materials, such as waxed papers, glassine, etc., are considered commercially as moisture-vapor proof barriers, but their transmission rates are so high that they cannot be considered for this particular problem. Ref. 6

c. Desiccants and Indicators

Desiccants are used in the individual package method to reduce and maintain the relative humidity at a safe level (Thirty per cent or below), by adsorption or absorption. When these desiccants become so saturated with water that they are no longer useful, they may be reactivated by drying in an oven. (Time and temperature dependent upon degree of saturation, characteristics, and quantity of desiccant.)

Relative humidity indicators are used purely for inspection purposes. They are composed of treated desiccant which changes color and indicates water content of the desiccant and the relative humidity of the air contained in the package. Ref. 24

Among the desiccants and indicators commercially available, the two most commonly used for this purpose are silica gel and Ducal Drierite (anhydrous calcium sulfate). They may be obtained in various grades and meshes.

The general factors governing the choice and quantity of desiccant required are:

1. Initial moisture content of the package.
   a. Relative humidity of air contained.
   b. Nature of materials enclosed.
2. Moisture penetration of the package.
   a. Moisture-vapor transmission rate.
   b. Anticipated storage conditions.
3. Relative humidity required in package.
4. Water capacity of the desiccant at the required humidity.

The relation of these factors to the quantity of desiccant required is shown in the following sample calculation:

Example:

1. Container size: 12 inches by 12 inches by 12 inches.
2. Atmospheric conditions at time of packaging: 100°F. at 95 per cent R.H.
3. R.H. required: 20 per cent.
4. Anticipated storage time: 1 year.
5. Anticipated temperature range: 100°F. to 40°F.
6. No hygroscopic material (dunnage) enclosed.

Moisture content of air at 100°F., 95 per cent R.H.	18.9905	grains
Moisture content of air at 40°F., 20 per cent R.H.	0.5722	grains
Moisture to be removed	18.4183	grains
or	0.0026	pounds

Moisture-vapor transmission rate of barrier for 100 square inches per 24 hours at 100°F., 95 per cent R.H.	0.05	grams
Surface area of barrier	864	square inche
Anticipated storage time	365	days

Amount of water penetration of the barrier equals:

0.05 x 8.64 x 365 = 157.68 grams water per year
or 2433.38 grains water per year
or 0.3469 pounds water per year.

Silica Gel

Equilibrium water content at 40°F., 20 per cent R.H.	15	per cent
Residual water content	6	per cent
Per cent effective capacity	9	per cent

$$\text{Solid Barrier} - \frac{\text{Water present}}{\text{Effective capacity}} = \text{pounds of desiccant required.}$$

$$\frac{0.0026 \text{ lbs.}}{0.09} = 0.029 \text{ pounds.}$$

Flexible Barrier - $\frac{\text{Water present plus water penetration}}{\text{Effective capacity}}$ = pounds of desiccant required.

$$\frac{0.0026 \text{ pounds} + 0.3469 \text{ pounds}}{0.09} = 3.88 \text{ pounds.}$$

Drierite, Ducal (Anhydrous Calcium Sulfate)

Total absorption capacity	26.5 per cent
Residual water (due to handling; etc.)	2.0 per cent
Per cent effective capacity	24.5 per cent

Solid Barrier - $\frac{\text{Water present}}{\text{Effective capacity}}$ = pounds of desiccant required

$$\frac{0.0026 \text{ pounds}}{0.245} = 0.01 \text{ pounds.}$$

Flexible Barrier - $\frac{\text{Water present plus water penetration}}{\text{Effective capacity}}$ = pounds of desiccant required.

$$\frac{0.0026 \text{ pounds} + 0.3469 \text{ pounds}}{0.245} = 1.4 \text{ pounds.}$$

The above calculations were based upon data furnished by the Davidson Chemical Company and the W. A. Hammond Drierite Company. The results indicate the Ducal Drierite is the better desiccant for static storage problems.

The following are two formulas specified by the Armed Forces for calculating the amount of "Silica Gel (Grade A) necessary for 18 month storage periods under moderately severe conditions. Ref. 21

Flexible containers (Less than 0.05 gr./100 sq.in./24 hr. water vapor permeability):

$$\text{Pounds of desiccant} = \frac{A}{10} + \frac{D}{2}$$

where

A = area in square feet of moisture barrier.
D = pounds of dunnage (hygroscopic material) enclosed in the package.

Solid containers (volume greater than 100 cubic inches):

$$\text{Pounds of Desiccant} = \frac{V}{22{,}000} + \frac{D}{2}$$

where

V = volume of container in cubic inches.

D = pounds of dunnage (hygroscopic material) enclosed in the container.

d. Sealing

Two methods of sealing flexible barriers consist of tapes and heat-seals. Tapes are unsatisfactory due to their higher moisture transmission rate. Heat-sealing is the actual fusing of the barrier material to make a positive seal. It is the preferred method and is used exclusively by the Armed Forces. Ref. 3

Good heat seals depend upon three basic factors. They are, in relative order of importance: temperature, time, and pressure. Ref. 6

The temperature factor is the most important because the uniting surfaces must be brought to a temperature at which they will become adherant.

The time should be the minimum amount required to fuse the material.

The pressure applied to the seal should be sufficient to insure an even, smooth joint without distortion.

Thermostatically controlled bench and hand-type sealers are available commercially. The sealing pressure on these units is applied by a clamping, rolling, or sliding action. The manufacturer of the barrier materials used, however, will normally specify the proper heat-sealer for their product.

e. Paper Wrappers and Wadding

When using paper for dust protection or wadding, care must be taken that only noncorrosive paper comes in contact with metal surfaces and that the paper used is dry. A large number of these papers is available.

Since paper is the most widely used medium for storage and shipping purposes, it would be impractical to include all types in this report. Ref. 25

f. Equipment

The equipment needed for packaging items for storage depends largely upon the materials that are used. Shears, knives, etc., would naturally be common to all. Additional special equipment such as spray guns, heat sealers, dip tanks, etc., are normally specified by the supplier.

g. Selection of Barrier Materials

The selection of a barrier depends mainly upon the moisture-vapor transmission rate, sealability, strength, aging qualities, inflammability, and chemical inertness.

Table I is a general summary of barrier materials listing their various properties from a packaging viewpoint. Ref. 6

BIBLIOGRAPHY

BOOKS

1. Corrosion Handbook - Uhlig.
2. Handbook of Plastics - Simonds, Weith, and Bigelow.
3. Handbook of Preservation, Packaging, and Packing of Naval Aeronautical Material (Navaer 00-85-A-502).
4. Heating and Ventilating Guide (1949)
5. Modern Plastics Encyclopedia.
6. Modern Packaging Encyclopedia.

BULLETINS

7. ASTM - D - 697 - 42T, Test for Water Vapor Permeability.
8. ASTM - D - 830 - 45T, Test for Water Vapor Permeability.

PERIODICALS

9. Protective Packing for Shipment and Storage - J. E. Foley, Corrosion and Material Protection (September, October, 1947).
10. Dehumidification Protects Materials from Deterioration - George C. Wells, Heating, Piping, and Air Conditioning (August, 1948).

PERSONAL INTERVIEWS

11. Mr. W. D. Long, In Charge, Package Test Laboratory, Wright Field.
12. Mr. M. T. Bard, Director of National Account Sales, Airtemp Division, Chrysler Corporation.
13. Engineering Department, Airtemp Division, Chrysler Corporation.
14. Mr. C. I. White, Major Dealer Division, Frigidaire Division, General Motors Corporation.
15. Mr. E. C. Gibson, Engineering Department, Frigidaire Division, General Motors Corporation.
16. Mr. R. M. Reutlinger and Associates, Hulman Building, Dayton, Ohio.
17. Mr. Chris Eichner, The Cincinnati Cordage and Paper Company, Dayton, Ohio

SPECIFICATIONS

18. Army-Navy Aeronautical, AN-B-20-Barrier: flexible sheet, moisture proof.
19. Army-Navy Aeronautical, AN-D-6c, Dehydrating Agent (activated).
20. Army-Navy Aeronautical, AN-P-13a, Preservation and Packaging, Parts and Equipment.
21. Joint Army-Navy, JAN-P-116, Methods of Preservation.
22. Joint Army-Navy, JAN-P-131, Barrier Material: moisture-vapor proof, flexible.
23. Joint Army-Navy, JAN-B-148, Barrier Material: aluminum foil.
24. Joint Army-Navy, JAN-D-169, Desiccants (activated).
25. Joint Army-Navy, JAN-P-121, Barrier-Material, greaseproof.

TABLE I

PROPERTIES OF PACKAGING MATERIALS

Properties	Vinyl Films Vinyl Chloride	Saran	Polyethylene
General			
Type of Material	Vinyl Resins	Polyvinylidene	Polyethylene
Clarity	Transparent to Translucent	Transparent to Translucent	Translucent or Colored
Mechanical			
Tensil Strength lbs./sq. in.	-	7,000-11,000	2,000
Folding Endurance	Good	Over 500,000	Very High
Heat Sealability	Good	Poor	Fair
Chemical			
Water-vapor Permeability grams/24 hr./100 sq. in./1 mil thick at 100°F. 90% R.H.	High Rate	0.2	1.0
Permeability to Gases	-	Very Low	High
Resistance to Acids	Good	Excellent Except H_2SO_4 and HNO_3	Excellent
Resistance to Alkalies	Good	Good-Except NH_4OH	Excellent
Resistance to Grease and Oil	Good	Excellent	Fair
Resistance to Organic Solvents	Soluble in Some	Excellent	Excellent
Permanence			
Resistance to Storage	No Change	Good	Excellent
Inflammability	Slow Burning	Self-extinguishing	Slow Burning

TABLE I - (Continued)

Properties	Pliofilm	Cellophane Plain	Cellophane Moisture Proof
General			
Type of Material	Rubber Hydrochloride	Regenerated Cellulose	Lacquered Regenerated Cellulose
Clarity	Transparent to Opaque	Transparent	Transparent
Mechanical			
Tensil Strength lbs./sq. in.	5,000	-	-
Folding Endurance	10,000-1,000,000	-	-
Heat Sealability	Fair	-	Good
Chemical			
Water-vapor Permeability grams/24 hr./100 sq. in./1 mil thick at 100°F. 90% R.H.	0.5-1.5	Very High Rate	0.2-1.0
Permeability to Gases	Low	High	Very High
Resistance to Acids	Good	Poor	Poor
Resistance to Alkalies	Good	Poor	Poor
Resistance to Grease and Oil	Good	Impermeable	Impermeable
Resistance to Organic Solvents	Soluble in Aromatic and Chlorinated Hydrocarbons	Insoluble	Insoluble
Permanence			
Resistance to Storage	Poor	Poor	Poor
Inflammability	Slow Burning	High	High

TABLE I - (Continued)

Properties	Cellulose Acetate	Ethyl Cellulose	Cellulose Acetate Butyrate
General			
Type of Material	Cellulose Acetate	Ethyl Cellulose	Cellulose Acetate Butyrate
Clarity	Transparent	Transparent to Opaque	Transparent to Opaque
Mechanical			
Tensil Strength lbs./sq. in.	9,000-14,000	10,000	6,000-9,000
Folding Endurance	-	4,000	-
Heat Sealability	Critical	-	Good
Chemical			
Water-vapor Permeability grams/24 hr./100 sq. in./1 mil thick at 100°F. 90% R.H.	High Rate	High Rate	High Rate
Permeability to Gases	High	Very High	High
Resistance to Acids	Poor	Fair	Poor
Resistance to Alkalies	Poor	Excellent	Poor
Resistance to Grease and Oil	Fair	Good	Fair
Resistance to Organic Solvents	Soluble Except in Hydrocarbons	Soluble in Most	Swells in Alcohols and Hydrocarbons
Permanence			
Resistance to Storage	Good	Excellent	Good
Inflammability	Slow Burning	Moderate	-

TABLE I - (Continued)

Properties	Aluminum Foil	Aluminum Foil-Paper-Aluminum Foil-Heat Seal Coating	Aluminum Foil-Adhesive-Paper-Microcrystalline Wax-porous Tissue
General			
Clarity	Opaque	Opaque	Opaque
Mechanical			
Tensil Strength lbs./sq.in.	2-135	29	19
Folding Endurance	4-18	154	55
Heat Sealability	None	Excellent	Excellent
Chemical			
Water-vapor Permeability grams/24 hr./100 sq.in./1 mil thick at 100°F. 90% R.H.	Negligible	Negligible	Negligible
Permeability to gases	Negligible	Negligible	Negligible
Resistance to Acids	Fair	Fair	Fair
Resistance to Alkalies	Fair	Fair	Fair
Resistance to Grease and Oil	Excellent	Excellent	Poor
Resistance to Organic Solvents	Excellent	Attacked by Aromatic and Active Solvents	Poor
Permanence			
Resistance to Storage	Uneffected	Uneffected	Uneffected
Inflammability	Not Combustible	Not Combustible	Not Combustible

TABLE I - (Continued)

Properties	Cellulose Acetate-Thermoplastic Adhesive-Aluminum Foil-Heat-Seal Coating	Aluminum Foil-Heat Seal Coating	Paper-Adhesive-Aluminum Foil-Vinyl Film
General			
Clarity	Opaque	Opaque	Opaque
Mechanical			
Tensil Strength lbs./sq.in.	21	19	High
Folding Endurance	240	18	Good
Heat Sealability	Excellent	Excellent	Good
Chemical			
Water-vapor Permeability grams/24 hr./100 sq.in./1 mil thick at 100°F. 90% R.H.	Negiligible	Zero	Negligible
Permeability to Gases	Negligible	Zero	Negligible
Resistance to Acids	Fair	Fair	Fair
Resistance to Alkalies	Fair	Fair	Fair
Resistance to Grease and Oil	Poor	Excellent	Excellent
Resistance to Organic Solvents	Attacked by Aromatic and Active Solvents	Attacked by Aromatic and Active Solvents	Poor
Permanence			
Resistance to Storage	Uneffected	Uneffected	Uneffected
Inflammability	Not Combustible	Not Combustible	Not Combustible

TABLE I - (Continued)

Properties	Scrim-Vinyl Film-Aluminum Foil-Vinyl Film	Scrim-Polyethylene-Aluminum Foil-Vinyl Film	Glass	Sheet Metal
General				
Clarity	Opaque	Opaque	Trans-parent	Opaque
Mechanical				
Tensil Strength lbs./sq.in.	High	High	High	High
Folding Endurance	Good	Excellent	-	-
Heat Sealability	Excellent	Excellent	-	-
Chemical				
Water-vapor Permeability grams/24 hr./100 sq.in./1 mil thick at 100°F. 90% R.H.	Zero	Zero	Zero	Zero
Permeability to Gases	Zero	Zero	Zero	Zero
Resistance to Acids	Very Good	Excellent	Excellent	-
Resistance to Alkalies	Very Good	Excellent	Excellent	-
Resistance to Grease and Oil	Very Good	Very Good	Excellent	Excellent
Resistance to Organic Solvents	Fair to Some Excellent to Others	Excellent	Excellent	Excellent
Permanence				
Resistance to Storage	Unaffected	Unaffected	Unaffected	Unaffected
Inflammability	Not Combustible	Not Combustible	Not Combustible	Not Combustible

TABLE I - (Continued)

Properties	Army Cocoon No. 1381	G. E. Cocoon No. 5249	Army Cocoon No. 1381 Black Mastic No. 5119
General			
Type of Material	Vinyl	Vinyl	Vinyl and Asphaltic Compound
Clarity	Opaque	Opaque	Opaque
Mechanical			
Tensil Strength lbs./sq.in.	1700	1550	-
Folding Endurance	-	-	-
Sealability	Excellent	Excellent	Excellent
Chemical			
Water-vapor Permeability grams/24 hr./100 sq.in./ recommended thickness at 100°F. 90% R.H.	High Rate	High Rate	Less Than 0.05
Permeability to Gases	-	-	-
Resistance to Acids	Good	Good	-
Resistance to Alkalies	Good	Good	-
Resistance to Grease and Oil	Good	Good	-
Resistance to Organic Solvents	Soluble in Some	Soluble in Some	-
Permanence			
Resistance to Storage	No Change	No Change	No Change
Inflammability	Noninflammable	Noninflammable	Noninflammable